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United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-064 May 1981

EPA

Project Summary

Electroplating Wastewater Sludge Characterization

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J. W. Meredith, J. A. McCarthy, and A. Procko

This project was initiated to provide information concerning the physical and chemical characteristics of electroplating wastewater treatment sludges and their performance in a leaching environment. Phase I of the study physically and chemically characterized representative electroplating sludges, determined their response to the EPA extraction procedure (EP), and determined the sensitivity of the parameters in the EP. Phase II involved laboratory testing to determine the performance of electroplating sludges under less aggressive leaching conditions than those present in the EP. Phase III experiments were designed to validate conclusions drawn from Phase II by conducting field tests on an actual segregated metal hydroxide landfill. Twelve electroplating shops with different types of production were sampled to supply sludges for the study.

Two variables were found to have a major effect on the results obtained by the leaching procedures tested during Phase I: the composition and amount of free and interstitial wastewater present in the sludge, and the pH of the final extract. In general, it was found that electroplating wastewater treatment sludges do not leach heavy metals at a significant rate when deionized water is used as the leaching medium. Mildly acidified leaching water results in higher rates of heavy metal leaching. A sample of combined leachate and runoff from a real world segregated hydroxide landfill was found by analyses to pass drinking water standards.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The American Electroplaters' Society (AES) and the U.S. Environmental Protection Agency's (EPA) Industrial Environmental Research Laboratory (IERL) cooperated in this three-phase study of sludges from electroplating wastewater treatment systems under EPA Cooperative Agreement No. R880026-01. The problem of disposal and handling of solid wastes from electroplating wastewater treatment systems has been difficult and complex. This difficulty has been at least partially due to the void of knowledge concerning the physical and chemical characteristics of the sludges and their performance in a leaching environment. The project discussed here was initiated to help fill this void of information and in the process establish a method which may be applicable to other industry groups interested in learning more about their wastes.

Twelve electroplating shops which represented a broad range of plating operations were visited and sludge samples from their wastewater treatment systems were collected. Under

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Phase I of the testing, each one of these sludges was subjected to a battery of experiments designed to characterize them physically and chemically, and also to determine their response to the EPA Extraction Procedure (EP). The variables associated with the EP (pH, temperature, volume of dilution water, etc.), and their effects on the leachability of the sludges were also tested as part of the program.

Under Phase II testing, the sludges were subjected to a dynamic leaching procedure where deionized water and acidified deionized water (to resemble acid rain), were used as the leaching medium. A dynamic test such as this was desired to test the leaching tendencies of electroplating sludges in an environment which is not as aggressive as the EPA-EP. Simplicity in the test procedure was desired to minimize the test variables which could affect results. The only variables were the sludges tested, the leaching water composition, and the hydrostatic head.

One of the 12 plants sampled had a captive segregated hydroxide landfill which it used to dispose of its wastewater treatment sludge. Under Phase III of this study, samples of leachate and sludge from this site were collected and analyzed. Sludge samples from various depths in and under the landfill were collected to test the downward migration of heavy metals.

Summary of Results

Some of the experiments designed for this project were conducted numerous times and thus allowed for valid conclusions to be drawn. Other experiments were conducted only once or twice to indicate whether or not the test variable had any significance. The effect of pH on the leachability of metals from plating sludges was one of the variables tested extensively. As expected, the tests showed that pH very strongly affected the concentration of metals in the EP extract. Most metals were highly soluble at low pH's and decreased monotonically in solubility as pH increased. Some metals reached a minimum solubility and began increasing again as pH was raised further. Before the concentration level at which EPA considered a material hazardous was increased from 10 to 100 times the drinking water standards, the composition and relative proportion of supernatant and interstitial waters was found to have a pronounced effect on the ability of the sludge to be classified as nonhazardous by the EPA-EP test.

Other experiments showed that the amount of dilution water had little impact on EP test results when conducted at pH = 5. Temperature also had little or no impact on test results when extraction temperatures were within the range allowed in the test protocol.

Allowing the sludge to age several months in an open beaker yielded dramatically reduced metal levels in the EP extract for the one plant's sludge that was aged. It is speculated that some form of curing took place during the aging process which structurally or chemically tied up the metals, making them unavailable for dissolution. Other tests indicated that the more metal present in the sludge, the higher will be the metal levels found in the EP extract.

Results of Phase II dynamic leach tests with deionized water showed that the mass of metals leached per day is very low. The wet weight of the samples leached was approximately 200 gm. One barium test result showed 4 mg/day but no other test leached a metal at a rate as high as 0.7 mg/day after the first day. There was little correspondence between the dynamic test results and those from EP extractions in terms of the amounts of metal leached.

The vast majority of metals analyzed during dynamic testing were present either below detectable levels or very close to the detectable levels after the first day. Dynamic tests conducted with acidified deionized water showed higher metal levels being leached but of the metals considered hazardous under RCRA, only cadmium concentrations were significantly increased in the leachate when the acidified water was used.

The actual landfills sampled under Phase III of this study generated results tending to verify the observations made during Phases I and II. Samples of sludge were taken at various depths into the bed along with soil samples below the bed and a leachate sample.

All of the solid and sludge samples were subjected to the EPA Extraction Procedure (EP) and the water sample was analyzed for its concentration of metal ions. After at least six years of unprotected exposure to the elements, the sludge in the older of the two landfills showed higher EP results than did the soil levels below it. Except for Mn, the soil samples below the old landfill are not substantially different from the background soil sample taken. To determine if the heavy metals had been merely washed away over the years, sludge samples were tested for their total Cr content. These tests proved that a substantial quantity of Cr still remained in the sludge and that even the aggressive nature of the EP could only remove a small portion of it. Soil from 17 inches below the sludge interface yielded EP results that were indistinguishable from the background soil results. Perhaps the most striking test result of this phase of the study is that the actual leachate from a landfill which contained electroplating wastewater treatment sludges yielding very high EP results for five metals would readily pass currently proposed drinking water standards, except for Mn.

Conclusions

The following variables were found to have a major effect on the results obtained by the leaching procedures tested during Phase I:

- *The composition and the amount of interstitial wastewater present.* Sludges with higher solids concentration consistently performed better in the leaching tests. The EPA Extraction Procedure dictates that the initial filtrate be added to the EP extract fluid before metal analyses are conducted. High metals levels in the filtrate, which would wash out very rapidly and not be a continuous problem, combined with low solids content in the sludge, may result in higher metal levels in the EP extract fluid than the solids portion of the sludge alone would account for. It is therefore likely that dewatering of low solids content sludges would improve the results of the leaching test.

- *The pH of the final extract.* Metal hydroxides follow a generally predictable solubility curve with pH; when the effects of the interstitial water are taken into consideration, the sludges tested generally followed this relationship. Thus, with a pH maintained at 5.0, as in the EPA Extraction Procedure, relatively large amounts of metals are and would be expected to be solubilized; at values closer

to neutral or those produced by the natural alkalinity of the sludge, greatly reduced amounts of metal are leached. This is significant because in a segregated hydroxide landfill, the alkalinity of the sludges would, under most circumstances, maintain the pH much higher than the 5.0 used to simulate the conditions of co-disposal with organic materials.

- *Mass transfer limitations.* This effect, which is not measured by any equilibrium type of leaching test, tends to reduce further the amount of metals transferred to leachate in a segregated landfill.

  Dynamic testing has indicated lower metal values in the leachate than reported by the EPA-EP, an equilibrium type of test. Dynamic tests with different head pressures and water flow rates support the conclusion that the leaching rate is controlled by the diffusion rate of the metal ions through the sludge mass and that the quantity of water used has little impact on the quantities of metal leached.

These additional observations have been drawn from all three phases:

- After the initial flushing of interstitial and supernatant waters, electroplating wastewater sludges do not leach heavy metals at a significant rate when leached with deionized water.

- Due to its low pH, acidified water has an aggressive leaching effect on certain metals found in electroplating sludges. However, of the hazardous metals only Cd was leached at a substantially higher rate with acidified water than with deionized water. Since Cd was present in only one of the sludges tested with acidified water and since one sample cannot be used to draw a conclusion, further testing should be conducted to verify this observation for Cd.

- Under field conditions tested, electroplating wastewater sludges do not leach significant quantities of heavy metals when disposed of in a segregated hydroxide landfill. Leachate collected from an actual segregated landfill contained metal concentrations well below EPA interim primary drinking water standards for all metals currently proposed as being hazardous under RCRA—even before dilution. This applies directly only to the conditions studied but indicates that a properly designed and managed disposal site need not incorporate extravagant leachate collection techniques to prevent any environmental harm.

- Electroplating sludges resist leaching of heavy metals unless subjected to aggressive leaching procedures. While sludges may contain high concentrations of a metal, such as Cr, even the EPA Extraction Procedure removes only a small fraction of the contained metal.

J. W. Meredith, J. A. McCarthy, and A. Procko are with CENTEC Corp., Reston, VA 22090.

***Alfred B. Craig, Jr.** is the EPA Project Officer (see below).*

The complete report, entitled "Electroplating Wastewater Siudge Characterization," (Order No. PB 81-190 928; Cost: $9.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
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The EPA Project Officer can be contacted at:

Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

• U.S. GOVERNMENT PRINTING OFFICE: 1981 -757-012/7125

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